1 MW Fuel Cell Power Plant
Final Report

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Disclaimer

Abstract

Fuel cells have attracted market interest in the power utility industry because of their environmental impacts and their potential for premium or assured distributed generation applications at a customer's facility. This report describes an application of a utility owning and controlling a multiple fuel cell unit power plant at a commercial customer location. It is the nation's largest assured power commercial fuel cell system to date.

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Executive Summary

Fuel cell technology can play a potentially significant role as a distributed generation resource at customer facilities. This project is a demonstration of new technology that is needed for utility control of multiple fuel cell power plants at a single location. The IFC 200 kW fuel cell is the only commercially available product but many utility customers have power requirements over 200 kW. Control technology was unavailable to allow multiple fuel cell units to seamlessly switch between grid-parallel and grid-independent mode of operation, and load share in grid independent operation. Five PC25™ Model C fuel cells, connected in parallel, produce one megawatt of electricity and are the primary source of power for power the US Postal Service general mail processing facility in

Anchorage, Alaska. The fuel cell power plants are owned, operated and was installed by Chugach for the Postal Service.

Introduction

Chugach Electric Association (Chugach) teamed up with the US Postal Service to install a 1 MW fuel cell power facility. This project includes many features never offered in an onsite fuel cell system and required several years of significant effort on the part of the sponsors and engineers responsible for its development. Research, development, manufacture and installation of the approximately $5.5 million fuel cell system was funded, in part, by Chugach, the US Department of Defense, US Postal Service, Cooperative Research Network of the National Rural Electric Cooperative Association and the Electric Power Research Institute. New technology developed for the project, and largely funded by the US Army Corps of Engineers assures the facility will continue to operate uninterrupted during a grid outage.

Results and Discussion

Installation

The five 200 kW fuel cells were connected and began operation in March 2000. The 1 MW Fuel Cell Power Plant, with multi-unit control technology, became fully operational in August 2000. Its normal mode is operating at 1 MW output in parallel with the Chugach grid, dispatched from Chugach's power control center. This meets all the power requirement of a post office facility, that has a peak load of approximately 800 kW, and excess power is fed into the Chugach grid.

Upon detecting a Chugach grid disturbance or outage, the SMS will disconnect the fuel cell power plant and post office facility from the Chugach grid. The transfer occurs within ¼ cycle and the 5 fuel cells electrical output is reduced to match the post office facility load. When power is restored to the Chugach grid and the grid is stable, the SMS automatically transfers back to the grid-connected mode within ¼ cycle.

This is the first use of a multiple fuel cell unit installation as a SCADA controlled distributed generation asset by an electric utility. The automatic transition appears seamless, eliminating the need for conventional uninterruptible power supplies and stand-by generators.

The development of new control systems encompass three separate elements:

1. Development of a control system that allows 5 fuel cell power plants to have the ability to load share and operate as a single unit in the grid independent operating mode.

2. Development of a high speed switching control system called a Site Management System (SMS) that allows the fuel cell power plant to carry the post office building should the grid power be unavailable. The high-speed switching system permits these transitions to occur seamlessly; that is, without a noticeable interruption in power to the post office building.

3. Development of the communication interface for Chugach's power control center to control the fuel cell power plant and to coordinate fuel cell transfer between the grid-connect and grid-independent load operating modes.

Mean Time Between Failure (MTBF)

Unscheduled shutdowns of individual fuel cells occurred during the 1-year test period. There were also numerous developmental upgrades of parts and software resulting in scheduled shutdowns. Attachment 1 is an excel spreadsheet that describes the shutdowns, by fuel cell, due to faulty parts or signals.

The following table provides hours of operation and output by fuel cell.

Fuel Cell ID Number	Operating Hours	MWHours
9186	8952	1488
9187	8841	1534
9188	9328	1614
9189	9459	1623.7
9190	8902	1539.6

Cost Benefit Analysis

Some Chugach benefits are intangible and will only be realized if fuel cell capital costs drop and a competitive fuel cell market develops.

Capital: The project capital costs were approximately $5.5 million. This amount includes significant R&D expense, largely associated with the site management system, which would not reoccur in other installations. The capital cost estimates below reflect what the next project may cost Chugach for a similar installation.

Item	Cost
5 fuel cells	$3,200,000
Installation	$1,100,000
SMS	$ 300,000
	$4,600,000

Post Office Perspective: The Post Office prepaid $1 Million for approximately 28 million kWh (5.5 years of usage), approximately 3.6 cents per kWh. This was a negotiated amount and does not tie to project costs or Chugach's standard commercial electric service rates. From the Post Office's perspective, its cost of power is about ½ as much as grid power service, part of its building heating is free, and there is no need for its standby diesel generator or its UPS system.

Chugach Perspective: Chugach's perspective as the owner and operator is the installed and operating costs exceeds the current project benefits. As noted earlier, if a fuel cell market develops, intangible benefits may increase Chugach's project benefits.

There are two revenue streams Chugach recovers from project electric sales. One is the revenue prepaid by the Post Office at approximately 3.6 cents per kWh. The other is electricity generated in excess of the Post Office needs that goes into the Chugach electric grid. The electricity sales to the grid are priced at 2.5 cents per kWh and this is the avoided fuel expense Chugach is willing to pay to independent power producers.

The variable costs (parts, fuel and labor) of the project are approximately 6.15 cents per kWh.

Based on 2001 Projections	Annual kWh	6,570,000
2.73 Maintenance Cents per kWh	Maintenance	$ 179,107
3.42 Fuel Cents per kWh	Fuel	$ 224,694
6.15		

The major future maintenance costs will be for replacement of fuel cell stacks at the end of the stacks' useful life. Chugach expects the useful life of a stack will, at a minimum, be 40,000 hours. Operating the fuel cells at ¾ loaded is expected to increase stack life but the numbers of fuel cells in operation is too small for statistical evaluation. A new stack may cost $250,000 and IFC suggests it will sell reconditioned stacks for less. If we treat stack replacement as a variable maintenance cost, assume the stack lasts 48,000 hours, costs $250,000, running at ¾ ouput produces 7.2 million kWh, then this adds 3.5 cents per kWh to our variable maintenance expense.

Reliability

Since the project was declared commercial in November 2000, the availability exceeds 97%. Availability data prior to this covers the testing and commissioning period where events would distort availability calculations. The data between November and March are shown in the following table.

Cell ID #	Availability	Unscheduled Shut-downs	Service and Standby Hours	Unscheduled Hours	Hours in Time Period
9186	97.2%	4	2798	82	2880
9187	99.8%	1	2875	5	2880
9188	98.9%	7	2847	33	2880
9189	97.4%	4	2806	74	2880
9190	99.1%	2	2853	27	2880

Reliability including attempted fuel cell unit starts versus actual fuel cell starts was not recorded until recently. Fuel cells don't always start on the first attempt after being out

of service for maintenance. One fuel cell was out of service for 4 hours in March and it took 3 attempts to start it.

Thermal Output

Thermal output from the fuel cells is provided to the Post Office at no charge and therefore tracking the output has not been a priority for Chugach. However, in March 2001, Chugach provided 13.43 million Btu to the Post Office. And, the Post Office reports that its boiler has only been fired once this winter. The boiler is the main heating source in the Post Office, but there are other heating systems as well.

Certification

Chugach certifies that the fuel cells have been in operation for 1 year and the activity required under the agreement with DOE is complete.

Project Picture

A project picture is included as an attachment.

Conclusions

Chugach was able to demonstrate a control system for fuel cells that would satisfy both the electric utility expectations for a SCADA controlled distributed resource and the customer expectations of a premium power supply for an 800 kW facility.